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Addressing requests for emergency ultrasonographic examinations when implementing teleradiology services

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Abstract
Purpose: To prospectively assess how to address requests for ultrasonographic examinations when setting up an on-call teleradiology service.
Materials and methods: An analytical prospective study was performed from January 2012 to December 2012 inclusively. All requests received for after-hours ultrasonographic examinations during this period were analyzed. Ultrasound requests were classified as being postponable until working hours, replaceable by an alternate cross-sectional imaging modality, or urgent and needing to be performed after hours.
Results: A total of 176 requests for ultrasonographic examinations were analyzed. They predominantly included requests for abdominal and pelvic ultrasonographic examinations (63%). Thirty-nine requests (22.2%) were considered as postponable, 49 (27.8%) as replaceable and 64 (36.4%) as both postponable and replaceable. Twenty-four requests (13.6%) were considered as urgent; they consisted of 10 requests for venous duplex Doppler ultrasonographic examinations of the lower limbs, eight requests for testicular ultrasonographic examinations, five for pelvic ultrasonographic examinations and one for soft-tissue ultrasonographic examination. In these urgent cases, realistic options were either to transfer the patient to another institution or to train emergency department physicians in ultrasonography for local handling.
Conclusion: Although the need for addressing requests for ultrasonographic examinations should be taken into account when setting up an on-call teleradiology service, it should not impede such plans.

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The number of requests for imaging studies has significantly increased over the last few years, particularly those arising from emergency departments [1]. In the same time, the number of practicing radiologists is markedly insufficient in France. Some regions, such as Lorraine, are particularly affected by the lack of such specialists. In 2012, 13% of the 263 radiologists practicing in Lorraine were older than 65 year-old [2]. In light of this, the importance of teleradiology services continues to increase in order to guarantee a 24-hours a day and seven days a week access to imaging evaluation [3]. In the Lorraine region, a teleradiology project was initiated in 2008 and has been under evaluation since 2010 [4]. It is planned that our hospital will handle, jointly with the Metz-Thionville University Hospital Center, an on-call teleradiology service from 2014 on.

The question of handling requests related to ultrasonographic examinations arose when considering how to successfully implement an on-call service for interpretation of remotely acquired imaging examinations. In effect, if the on-duty or on-call radiologists are replaced by a regional on-call teleradiology service, then a radiologist will no longer be able to physically perform on-site and bedside ultrasonographic examinations.

Bearing this in mind, we decided to assess all the after-hours requests for ultrasonographic examinations received in our hospital over a year period. The main objective of this study was to determine whether after-hours ultrasonographic examinations are actually indispensable. The secondary objective was to determine in which situations emergency ultrasonographic examinations are essential and to consider what solutions would be appropriate to handle such cases.

Materials and methods

An analytical prospective study was performed by the medical imaging service of the Hôpital d'Instruction-des-Armées Legouest in Metz, France over a one-year period spanning from 1st January to 31st December 2012 inclusively. Due to the solely observational nature of the study, patients' signed consent was not required.

Patient selection

This study reviewed all requests for ultrasonographic examinations received after hours in 2012 by our medical imaging service. Our service is part of a 200-bed general hospital with no pediatric, gynecological or obstetrics departments but an emergency department that received 21,672 patients in 2012. Because there is no pediatric activity, all patients referred for ultrasonographic examinations were at least 15 years and three months old.

Requests were considered as ''after-hours'' if received from 6 pm to 8 am on weekdays, and 24/24 on Saturdays, Sundays and national holidays.

Exclusion criteria were ultrasound examinations requested by radiologists in addition to other imaging modalities or ultrasonography performed during surgical draining procedures.

Questionnaire

Every request for ultrasonographic examination was recorded by the on-duty radiologist using a dedicated data collection form.

A first section focused on recording patient demographics and included gender, age, and department that issued the request. The form then contained free-text fields in which the radiologist could record data about the indication for the requested ultrasonographic examination: clinical examination, laboratory results and diagnostic hypotheses. The third part of the form was used to record data about the imaging procedure performed: type of imaging examination requested, examination actually performed and time between request and examination.

Data analysis

All questionnaires were analyzed by a medical imaging resident (C.J.L., sixth semester) and a senior radiologist with eight years' experience (A.G.). The requests were first analyzed to determine the maximum time between the request and ultrasonographic examination for each indication and to ensure that good radiology practices had been observed (as laid down by the French Society of Radiology in *Guide du bon usage des examens d'imagerie médicale* [Guidelines for proper use of medical imaging] amended in 2013 [5] and *Guide des indications d'imagerie pour les urgences de l'adulte* [Guidelines for indications for emergency imaging in adults] in 2004 [6]).

To ensure that our cases were properly correlated within these guidelines, disease criteria were established by an expert committee comprising an emergency clinician, an intensive care doctor, a general surgeon, an orthopedic surgeon, a gastroenterologist, an internist and a radiologist.

These disease criteria were also used to sort cases based on severity: severe sepsis or intensive care for abdominal infection (cholecystitis, pyelonephritis), concurrent pregnancy or renal failure for pyelonephritis, renal failure, single kidney or fever in cases of suspected renal colic.

Depending on both the indication and the guidelines, each request was assigned to one of the three following categories:

- postponable until working hours;
- replaceable by an alternative slice imaging modality;
- urgent (i.e. not postponable), not replaceable and needing to be performed after hours.

The replaceability of requests for ultrasound was first determined strictly based on good radiology practices, then, as a second step, by extending replacement indications to computer tomography (CT) examination and/or magnetic resonance imaging (MRI), without nevertheless diminishing diagnostic quality.

Data collection

The number of CT and MRI examinations performed after hours in our medical imaging service over the whole inclusion period was collected retrospectively from the Picture Archiving and Communication System (PACS) archiving

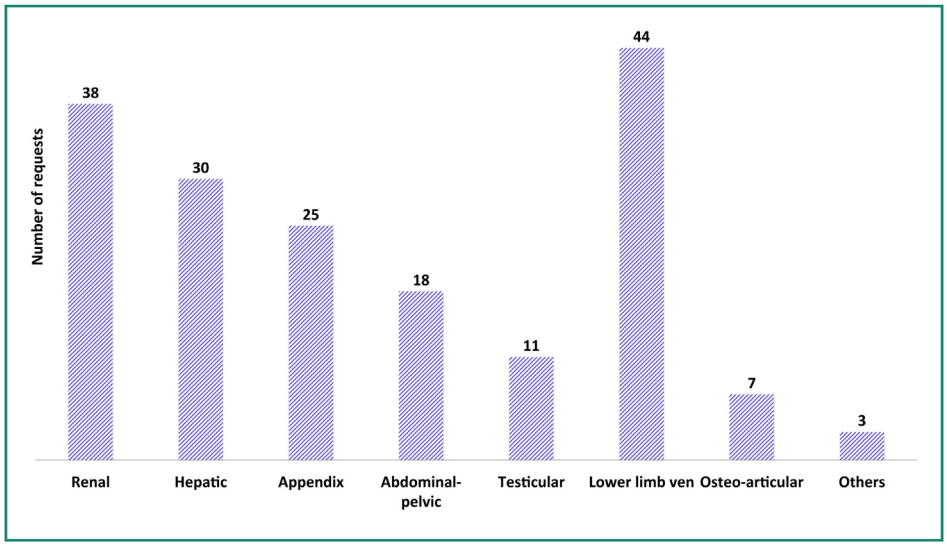

Figure 1. Bar chart shows the different ultrasonographic examinations requested. The majority of requests were for abdominal ultrasonographic examinations (111 requests, 63%), followed by venous duplex Doppler ultrasonography of lower limbs (44 requests, 25%) and testicular ultrasonographic examinations (11 requests, 6%). Lower limb ven. indicates venous Doppler ultrasound of the lower limbs.

system database of our center (Impax V6, ES; AGFA Technical Imaging Systems, Ridgefield, USA).

Statistical analysis

Data analysis was performed using SAS®, version 9.2 (SAS Institute). Descriptive statistics were produced for the study population, then various variables were processed using univariate analysis depending on the frequency and the mean value of the variable.

Results

In 2012, 1014 CT examinations, 28 MRI examinations and 168 ultrasonographic examination were performed after hours.

One hundred and seventy-six requests for emergency ultrasonographic examination were received for 70 (39.8%) men and 106 (60.2%) women; the mean patient age was 46.8 years ± 23 years (SD) (range: 15.9—96 years). Two patients had two requests each.

The requests were for the most part issued by the emergency department (151 requests, 85.8%), followed by the general and orthopedic surgery departments (11 requests, 6.2%), then internal medicine (eight requests, 4.5%) and the intensive care unit (six requests, 3.4%).

Most requests were for abdominal-pelvic ultrasonographic examination (111 requests, 63%), followed by venous duplex Doppler ultrasonographic examination of the lower limbs (44 requests, 25%) and testicular ultrasonographic examination (11 requests, 6%) (Fig. 1).

A total of 168 (95.5%) ultrasonographic examinations were performed. For eight (4.5%) requests, CT examinations were performed directly during the after-hours period instead of ultrasound (three cases of renal colic, two cases of appendicitis, 1 case of postoperative assessment of pancreaticoduodenectomy in an intensive care patient and two cases of abdominal pain with abnormal liver function tests).

Thirty-five (19.9%) of the ultrasound examinations performed were followed by a CT examination, and one (0.6%) by MRI examination (quadriceps tendon rupture). Most often additional CT examinations were performed following abdominal-pelvic ultrasonography (30 patients with 16 suspected cases of appendicitis, 10 abnormal liver function tests and four suspected cases of renal colic).

The average time between the request for imaging examination and the procedure was one hour and 33 minutes (range: 0—20 hours).

The majority of requests (58%) were received during weekends during the daytime (from 8 am to 6 pm on Saturdays, Sundays and national holidays); 30.7% of the requests were received on weeknights (Monday to Friday, after 6 pm), and 11.3% on weekend nights.

In ten patients (5.8%), the symptoms were considered as serious (nine requests for abdominal ultrasonography of which 4 were replaced immediately by CT, and one request involving acute lower limb ischemia). In only one patient with abdominal pain during pregnancy, the request for ultrasonographic examination could not be replaced immediately by CT examination.

Forty-four (25%) of the requests for ultrasonographic examination were postponable, 33 (18.7%) were replaceable, and 23 (13%) were both postponable and replaceable. Postponable requests for ultrasonographic examination were mostly for abdominal ultrasonography ($n = 36$) and venous duplex Doppler ultrasonographic examination of the lower limbs ($n = 22$). Forty requests could have been replaced by CT examination. These requests were mainly for abdominal ultrasonography with 23 cases of suspected appendicitis, 15 requests for renal ultrasonography (13 patients with suspected renal colic, one patient with pyelonephritis and one patient with acute renal failure with gross hematuria), one patient with acute lower limb ischemia and one patient after pancreaticoduodenectomy. Sixteen requests could have been replaced by MRI. These cases involved gallstone detection ($n = 11$) and

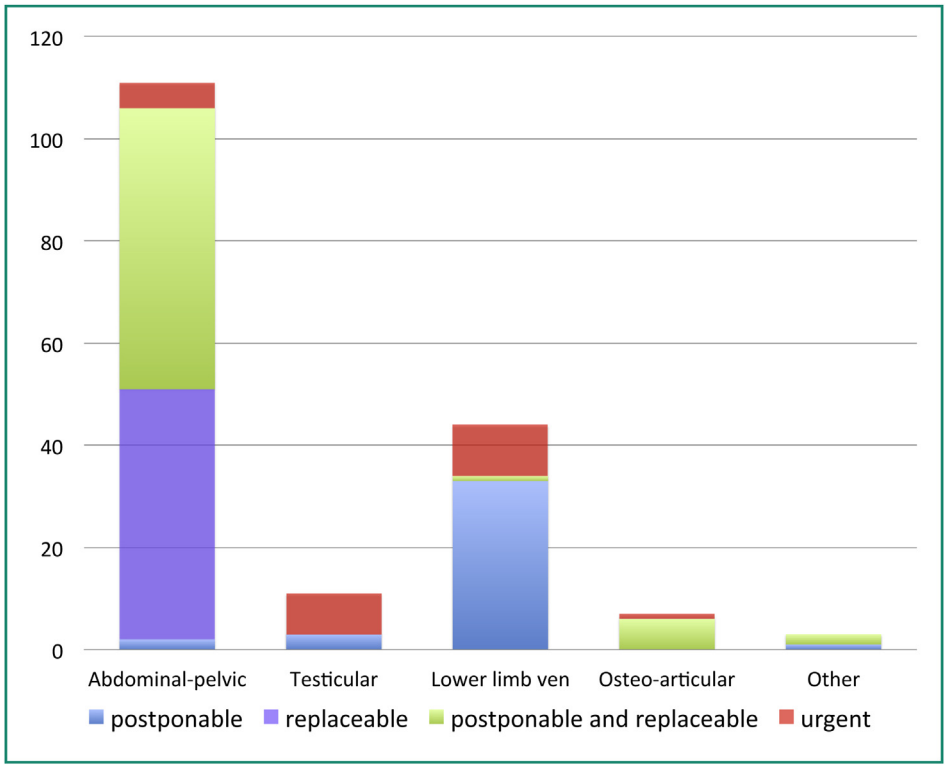

Figure 2. Bar chart showing how requests for ultrasonographic examinations were handled depending on the type of ultrasound when indications for replacing ultrasound by cross-sectional imaging modalities were extended. Requests for ultrasonographic examination were divided into four groups: urgent (needing to be performed after-hours), postponable (procedures that could be postponed until working hours), replaceable (procedures that could be replaced by CT or MRI examination), and both postponable and replaceable. Lower limb ven.: venous duplex Doppler ultrasonographic examination of the lower limbs.

osteo-articular MRI ($n = 5$). However, due to the limited availability of MRI in France after hours, these cases could also have been investigated by CT in order to detect possible complications and allow appropriate patient management without adding to the complexity of emergency department organization.

In strict accordance with good radiology practices, our study demonstrated that in 2012, 76 (43.7%) requests for ultrasound still needed to be fulfilled (i.e. non-postponable and non-replaceable). If the indications for replacing ultrasound by CT scanning were extended to include pyelonephritis, cholecystitis, hepatitis, hepatic colic, cholangitis and prostatitis, 39 (22.2%) of the requests for ultrasound were postponable, 49 (27.8%) were replaceable, and 64 (36.4%) were both postponable and replaceable (Fig. 2).

In all and over the whole year, if the indications for replacing ultrasound by slice imaging procedures were extended, 24 requests for ultrasound were considered as still needing to be fulfilled, i.e. 13.6% of all requests. These 24 cases comprised 10 requests for venous Doppler ultrasound of the lower limbs (requests received between Friday evening and Sunday morning that could not be postponed due to the 24-hour window for performing ultrasound), eight requests for testicular ultrasound (after exclusion of suspected testicular torsion by the senior surgeon with 1 case following minor injury, one post-operative patient, six cases of orchitis or atypical epididymitis due to its acute onset for which the surgeon wanted to exclude torsion of the hydatid of Morgagni), five requests for pelvic ultrasonographic examination and one request for soft tissue ultrasound to localize a foreign body.

Discussion

Although the impact of setting up an after-hours teleradiology service on the interpretation of slice imaging procedures has already been assessed [3,7], this is, to our knowledge, to first study to assess the need for ultrasound within such a service.

Our study shows that there is a need for after-hours ultrasound. In our hospital, 168 ultrasonographic examinations were performed after hours in 2012, representing 14% of all imaging examinations carried out (excluding X-rays).

If teleradiology services are used in the future, then the radiologist will not be able to physically go to the patient's bedside to perform ultrasonographic examinations. Nevertheless, such requests for ultrasound need to be taken into account. For this reason some facilities have separated the way they manage different radiology requests: slice imaging reports are sent for interpretation by a remote teleradiology service while ultrasonographic examinations are still performed by an on-duty radiologist, thereby reducing the radiologists' workload in smaller centers where the amount of after-hours work is proportionally greater. However, the main purpose of after-hours teleradiology services is to reduce the amount of after-hours work by sharing a service

between various hospitals. With this in mind it therefore seems aberrant to maintain specific on-duty radiologists just for ultrasonographic examinations.

Our analysis showed that venous duplex Doppler ultrasonographic examinations of the lower limbs accounted for 10 of the 24 requests for ultrasound that were considered as urgent. This arises from the current guidelines [6] that state that ultrasonographic examinations must be performed within a 24-hour window and cannot be replaced by another modality. Various solutions could be implemented in such cases. The first being to train emergency clinicians on how to perform 3-point compression ultrasonography using the North-American method [8], without exploration of the sural veins, followed by a second complete examination conducted by the radiologist during normal working hours. In France, non-radiologist clinicians who wish to perform ultrasonographic examinations must currently attend theoretical and practical training courses over a whole year and then be certified by national academic authorities via a nationally-recognized qualification. This training process is long but represents one of the more accessible solutions to form extensively-qualified teams of emergency clinicians.

To overcome the paucity of radiologists, one possibility would be to delegate a subset of procedures to radiology technicians, as it is legally done in the USA [9,10]. In 1999, Rosen et al. compared the diagnostic accuracy of on-site radiologists versus that of remote radiologists who interpreted 80 printed pelvic ultrasounds performed by on-site ultrasound technicians and found that the level of reliability was satisfactory [11]. However in France, in accordance with article L. 372 of the French Public Health Code and decree no. 97-1057 of 17 November 1997 on the acts and practice of French medical electroradiology technicians [12], technicians cannot perform emergency ultrasonographic examinations that are remotely interpreted by a radiologist because professional regulations state that a physician qualified in ultrasonography must always be present to ensure the procedure is performed correctly and take over if necessary. In the Lorraine region, a cooperation protocol enables radiology technicians trained in ultrasound to perform procedures duly delegated by a radiologist, however the latter must be able to physically assist the technician if problems arise [13].

Telesonography has been developed for specific situations such as isolated islands, ships or even spacecraft, with for example the Melody telesonography robotic arm [14]. This technique lets the remote radiologist ''touch'' the patient via a balanced robotic arm holding the probe, and visualize real time ultrasound video images. Despite the robot's good performances, this type of project has two main disadvantages: its cost (approx. 70,000 euros per center) and the evaluation of its use, which is limited to abdominal ultrasound. In addition, the tests for satellite transmission of ultrasound images were performed in pre-hospital care centers and emphasized the potential of this technique in isolated situations; however its application does not seem suitable for hospital procedures due to it being highly operator-dependent [15].

The most straightforward solution would therefore be to replace ultrasonographic examinations by other cross sectional imaging techniques, and more particularly CT. With recent improvements in dose reduction, CT scanning can now become the first-line imaging modality for a variety of clinical situations such as suspected renal colic [16—18]. We considered that ultrasonography could be replaced by CT for patients with suspected pyelonephritis, cholecystitis, hepatitis, hepatic colic or cholangitis and prostatitis. Indeed, in such situations, CT as a first line examination allows to exclude various serious conditions such as dilatation of biliary or urinary tract, abdominal abscess and thus help select the best therapeutic option. However, the extent to which teleradiology may alter routine medical practices is questionable because, according to the *Guide pour le bon usage professionnel et déontologique de la téléradiologie* [Guide to good professional and ethical practices in teleradiology] [19] drawn up by the French Professional Radiology Council (G4) and the French National Medical Council, ''a teleradiology service can only be achieved if overall quality requirements, both from a technical and medical point of view, are satisfactory''. Furthermore, the core issue of radioprotection needs to be addressed because if the implementation of teleradiology services results in an extension of the indications for replacing ultrasound, then the risk of over-exposure will increase due to the unavailability of ultrasonography.

When we extended the indications for replacing ultrasonographic examinations by other cross sectional imaging techniques, 24 (13.6%) requests for ultrasonographic examinations could not be replaced and were considered as urgent. These included venous duplex Doppler ultrasonographic examination, testicular or pelvic ultrasonographic examinations for patients with suspected testicular torsion and a request for soft tissue ultrasound to localize a foreign body.

In the absence of an experienced emergency-attending physician qualified to perform ultrasonographic examination, the only feasible solution for these urgent cases is to transfer the patient to another institution. Such transfers would generate extra costs and a delay in care for the patient (especially in cases of testicular torsion) that need to be assessed against maintaining the presence of an on-site, on-duty radiologist.

Our study has several limitations. First, it is possible that some requests for ultrasound that were immediately replaced by CT were not accounted for in our study. However, this does not negatively impact our results since it does not affect the overall number of non-postponable and non-replaceable ultrasound procedures. More importantly, our study was monocentric so our results can only really be transposed to hospitals with the same characteristics as ours, i.e. no pediatric or women's health departments. Nevertheless, in hospitals with pediatric or women's health departments, ultrasonography is often performed by pediatricians or gynecologists and not radiologists, thus supporting the idea of training clinicians in other medical specialties [20]. In addition, the absence in our hospital of a department of urology might have led to an over-estimation of what were considered to be urgent requests for testicular ultrasonographic examinations (eight out of the 24 requests considered as urgent in our study) since suspected cord torsion is an indication for immediate surgery and other indications for urgent exploration of the scrotum being limited. In the same way, Saturday mornings were considered as after-hours whereas in many other hospitals a radiologist

is on site during this period. Finally, we based our analysis on dividing the requests into various categories depending on disease criteria and some bias may have occurred due to subjectivity.

Conclusion

In conclusion, we have demonstrated that ultrasonography is a frequently requested imaging modality after hours in our hospital. In line with the applicable guidelines, replacement of ultrasonographic examination by other cross-sectional imaging examinations and/or postponement until working hours, 14% of the requests for ultrasonography still needed to be addressed after hours. For such urgent situations, realistic solutions seem to be either to transfer the patient to another institution or to train emergency department physicians in ultrasonography. Although the capacity to address requests for ultrasonographic examination should be taken into account when setting up an on-call teleradiology service, it should not impede such plans.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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